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Description

Mobile radio transmitting/radio receiving device with a tunable antenna

In radio communications systems, messages (for example voice, picture information or other data) are transmitted by means of electromagnetic waves. The electromagnetic waves are transmitted by means of antennas, with the carrier frequencies being in the frequency band intended for the respective system.

In addition to the requirement to restrict the dimensions of the antenna for mobile radio transmitting/radio receiving devices, there is also an increasing requirement for the capability to transmit and receive in different frequency bands. For this reason, antennas are required which can be used in a number of frequency bands.

When using conventional antennas, for example rod antennas as are used in particular in mobile parts, the required coverage of a frequency band which is as wide as possible, or of a number of frequency bands, cannot be ensured since the impedance and antenna gain of the antenna vary severely as a function of the frequency, so that it is impossible to use the antenna in certain frequency ranges.

Thus, in order to solve this problem, antenna systems have until now been used which comprise a number of antennas, each of which covers a specific frequency range.

Antenna systems such as these have the disadvantages that, firstly, they require more space and, secondly, the matching of the antennas to the individual frequencies from the respective frequency band is less than optimum.

The object on which the invention is based is to design a mobile radio transmitting/radio receiving device such that, while covering a wide frequency range, it ensures a virtually constant, stable antenna gain.

This object is achieved by the features of patent claim 1.

According to claim 1, the mobile radio transmitting/radio receiving device according to the invention has an electrically effective antenna body, in whose near field a dielectric body is mounted such that it can move, so that the dielectric body can be moved in the near field of the antenna body such that the extent to which the dielectric body and the electrically effective antenna body overlap in the near field is varied. The resonant frequency which can be set in this case becomes lower, the greater the extent of the overlap in the near field of the antenna body. In order to make it possible to adjust the extent of the overlap, means are, furthermore, provided for adjusting the position of the dielectric body. These adjusting means vary the position on the basis of at least one control signal, which is produced as an output signal by a control device and is passed to the adjusting means. The control signal is produced by the control device until the extent of the overlap ensures an optimum value of at least one physical variable, which represents a function of the transmission/reception quality of the radio transmitting/radio receiving device, and which is detected by detection means and is passed as an input signal to the control device.

The major advantage of the mobile radio transmitting/receiving device according to the invention is that the antenna gain is largely stable over a wide frequency range, which is achieved by regulating the variable or variables which represents

or represent the reception quality as an optimum value by moving the dielectric body in the near area of the antenna body, in which case

the extent of the overlap of the antenna body and of the dielectric body leaves the polar diagram of the antenna virtually unchanged, thus ensuring good matching over the frequency range. Furthermore, the arrangement has the advantage that the antenna (the antenna body) need not be moved, which is advantageous to the design of the mobile radio transmitting/radio receiving device, and the external electrical influence is minimized.

A major advantage of the development as claimed in claim 2 is that any directional electrical influence on the antenna by the user, in particular by his head, on the radio transmitting/radio receiving device is minimized, and vice versa.

The development as claimed in claim 3 makes it possible to minimize non-directional external influences simultaneously, since they have a greater effect the greater the electrically effective antenna length of an antenna, with, at the same time, the connection for the radio-frequency signal being applied through the slot which runs parallel to the longitudinal axis, so that the dielectric hollow body can move without impediment and without changing the length of the supply line for the radio-frequency signal.

One major advantage of the development as claimed in claim 4 is the provision of a simple device for adjusting the position of the dielectric body, which requires only one control signal.

A major advantage of the development as claimed in claim 5 is the provision of simple adjusting means for the position of the dielectric body, which require only one control signal, with the adjustment process being carried out in defined steps (step angles).

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Major advantages of the development as claimed in claim 6 are the flexibility and updating capability for implementation of the control process, which is facilitated by the use of (control)

software, and the capability to use already existing processors for controlling the mobile radio transmitting/radio receiving device according to the invention by the use of additional software, or by the adaptation of existing software.

Major advantages of the development as claimed in claim 7 are the simple and advantageous implementation of the control unit, and the capability to implement this switching mechanism as an integrated circuit in an expansion module.

The major advantage of the development as claimed in claim 8 is the high dielectric constant of ceramic, since the frequency range in which the antenna can be tuned, and can thus be used, increases in proportion to the magnitude of the dielectric constant of the hollow body that is used, and the purchasing costs are low, since ceramic bodies are produced in large numbers, for example as bodies for resonators.

The major advantage of the development as claimed in claim 9 is that this makes it possible to use the mobile radio transmitting/radio receiving device in a frequency range within which the ratio of the highest to the lowest frequency is at least 1.5 octaves.

The detection of the forward transmission power and backward transmission power as claimed in claim 10 as a physical variable which represents a function of the transmission/reception quality of the radio transmitting/radio receiving device allows simple implementation of the control (matching) for the antenna, since means which already exist in the radio transmitting/radio receiving device can be used for this purpose.

Exemplary embodiments of the invention will be explained with reference to Figures 1 and 2, in which:

Figure 1 shows a mobile radio transmitting/radio receiving device with a rod antenna, which is enclosed by a dielectric body in the form of a slotted hollow cylinder (illustrated in section form), in which case the dielectric body can be extended and retracted by means of a controlled electric motor.

Figure 2 shows a mobile radio transmitting/radio receiving device with a rod antenna, in which a dielectric body in the form of a rod is arranged parallel to the antenna, in which case the dielectric body can be extended and retracted using a controlled electric motor.

Figure 1 shows a mobile radio transmitting/radio receiving device SE with a transmitting/receiving antenna in the form of a rod antenna SA, in which case the maximum effective antenna length l_{max} for radio purposes is governed by the length of the rod antenna SA.

A dielectric body in the form of a rod SB is arranged parallel to the longitudinal axis of the rod antenna SA. The distance of the rod should not be excessively large in comparison to the wavelength, since the different phase delay times which would otherwise occur would result in a different polar diagram characteristic than that which is normal for rod antennas (monopole antennas).

Alternatively, the dielectric body may have any other desired geometric shapes. The only essential feature is that, when the dielectric body is introduced into the near field of the antenna, the antenna is tuned such that it is tuned to the current frequency.

The way in which the choice of the geometric shape is made depends in particular on the antenna and may, for

example, be determined by simulation or by trial installations.

The frequency range that is covered is increased by increasing the volume and increasing the dielectric constant of the dielectric body that is used.

The dielectric body can thus, for example, be manufactured from ceramic, since ceramic may have a dielectric constant of 88.

The dielectric rod SB is mounted such that it can move, in such a way that it can be extended and retracted by a drive wheel AR which is rotated forward or backward by an electric motor VM which, for example, is in the form of a stepping motor. In this case, the drive roller AR makes contact with it on one side, and a support wheel SR makes contact with it on the side of the rod SB opposite the point of contact - for support - so that the rotary movement of the drive wheel AR is converted to a linear movement of the rod SB, thus defining an extent M by which the the rod antenna SA and the dielectric rod SB overlap.

The (stepping) angle and the rotation direction are governed by the magnitude, the mathematical sign and/or the duration of a voltage (control signal) U_{ST} which is applied to the electric motor VM.

This voltage U_{ST} is a signal (control signal) which is produced at the output of a control unit (microprocessor) μP, and whose magnitude, mathematical sign and/or signal duration are/is dependent on an input variable EQ which is applied to the control unit μP.

The control unit μP controls the electric motor VM by means of the signal U_{ST} until a physical input variable EQ, which represents the reception quality of the radio transmitting/radio receiving device, has reached an ideal value (optimum).

In this case, the electric motor VM is first of all driven such that it always rotates the drive roller AR in a predetermined direction (default)

at the start of the control process. If the evaluation shows that the input variable EQ is moving away from the ideal value, the rotation direction is changed and the electric motor VM is driven until the input variable EQ has reached the ideal value.

Alternatively, it is also possible to start the control process from a defined start point, for example with the dielectric rod SB always being in the completely extended state - that is to say the extent of the overlap M or a length $l_{ANT,AB}$ which is covered by the rod SB is equal to the maximum electrically effective antenna link $l_{ANT,MAX}$ - and thus to set this start point reliably, initially, at the start of the control process. This procedure is necessary in particular when using the mobile radio transmitting/radio receiving device SE over a very wide frequency range, in which the ratio of the highest frequency to the lowest frequency is at least 1.5 octaves since, otherwise, it would be possible for a situation to occur in which an electrically effective antenna length l_{ANT}, which results from the difference between the maximum electrically effective antenna length $l_{ANT,MAX}$ and the antenna length $l_{ANT,AB}$ which is covered by the dielectric rod SB, has a magnitude corresponding to three quarters of that wavelength which results from the current frequency, so that the control process is ended, since the input variable EQ likewise reaches the ideal value in this situation. Since the object of the invention is not achieved in this situation, this value of the antenna length l_{ANT} is not desired. It is possible to prevent the process of controlling the antenna length l_{ANT} from ending on reaching this value if, for example, suitable control software is used to start the process of controlling the antenna length l_{ANT} at a minimum effective antenna length for radio purposes, which is obtained when the dielectric rod SB is fully extended, thus ensuring that the input variable EQ always

guarantees optimum matching of the antenna when it reaches the ideal value.

The (possibly preprocessed) input variable EQ is passed to the control unit μP from means EFM for detecting physical input variables EQ which are dependent on the extent of the overlap M, and which may be transformed by these means to a form that is required for the control unit μP.

Alternatively, the means EFM also detect a number of physical input variables EQ and may preprocess them, before passing them to the control unit μP, in which case the control unit μP checks, in a corresponding manner, whether a number of input variables have reached an ideal value.

Figure 2 shows a mobile radio transmitting/radio receiving device SE with a transmitting/receiving antenna in the form of a rod antenna SE, in which case a maximum effective antenna length l_{max} for radio purposes is determined by the length of the rod antenna SA.

A dielectric body in the form of a hollow body is arranged symmetrically with respect to the longitudinal axis of the rod antenna SA such that the longitudinal axis of the rod antenna SA coincides with the longitudinal axis of the dielectric hollow body HK. The diameter of the hollow body HK should be chosen such that the side walls of the hollow body are not excessively far away, with respect to the wavelength, since the different phase delay times which would otherwise occur would result in a polar diagram other than the normal polar diagram for rod antennas (monopole antennas).

In order to allow a radio-frequency signal to be passed to the rod antenna SA, a slot is provided parallel to the longitudinal axis of the rod antenna SA, through which the radio-frequency connection HF is passed such that the hollow body can be extended completely without

any impediment, that is to say covering the entire rod antenna, and can be retracted completely without any impediment, that is to say exposing the entire rod antenna.

Alternatively, the hollow body HK can also be designed without a slot, but the radio-frequency connection HF must then be routed through the lower opening of the hollow body HK, in which case the radio-frequency connection HF, and in particular its supply line, may need to be matched when the position of the dielectric hollow body HK is changed.

The dielectric hollow body HK is mounted such that it can move, in such a way that it can be extended and retracted by a drive wheel AR which is rotated forward or backward by an electric motor VM which is, for example, in the form of a stepping motor. In this case, the drive roller AR makes contact with it on one side, and the support wheel SR makes contact with it on the side of the hollow body HK opposite the point of contact - for support - so that the rotary movement of the drive wheel AR is converted to a linear movement of the hollow body HK, thus defining an extent M by which the hollow body HK and the rod antenna SA overlap.

The (stepping) angle and the rotation direction are governed by the magnitude, the mathematical sign and/or the duration of a voltage (control signal) U_{ST} which is applied to the electric motor VM.

This voltage U_{ST} is a signal (control signal) which is produced at the output of a control unit (microprocessor) μP, and whose magnitude, mathematical sign and/or signal duration are/is dependent on the input variable EQ applied to the control unit μP.

The input variable EQ is determined by detection means that are provided.

These detection means EFM may be designed such that they have a directional coupler RK, which outputs a forward transmission power and a backward transmission power from a transmission signal (this configuration of

the detection means can also be used with the embodiment of the invention described in Figure 1).

The forward transmission power is then first of all rectified by a first rectifier, and the rectified forward transmission power is then converted by a first analog/digital converter to a first digital signal. The backward transmission power is rectified by a second rectifier, and the rectified backward transmission power is then converted by a second analog/digital converter to a second digital signal.

The digital signals are applied as an input signal to the control unit μP, with the control unit μP being, for example, in the form of a (micro)processor with associated software. When the digital signals are applied, the processor μP checks whether any of the signals have reached an ideal value - no backward transmission power or minimum backward transmission power and maximum forward transmission power.

When this is the case, no control signal U_{ST} is produced, since there is no need to change the extent of the overlap.

If this is not the case, the processor μP first of all produces a first control signal U_{ST}, so that the adjusting device VM retracts the hollow body, or extends it, in particular starting from the default value. The input signals - forward and backward transmission power - which are applied to the processor, and which are changed by this process, are checked by the processor to determine whether they have reached the ideal values. If the values of the signals - forward and backward transmission power - are worse with regard to reaching the ideal values, then the rotation direction of the means VM for adjusting the position of the dielectric hollow body HK is changed. This is done, for example, by reversing the mathematical sign of the signal U_{ST}.

The signal U_{ST} is produced following the determination of the correction direction until the forward and backward transmission powers have reached their ideal values.

Alternatively, only one of the two variables - forward transmission power or backward transmission power P_R - may be used as the controlled variable for this control loop, that is to say can be detected by the means EFM, with the processor μP checking whether it has reached the ideal value - minimum or no backward transmission power or maximum forward transmission power.

As an alternative to the use of an additional processor μP, it would also be feasible to upgrade already existing processors by means of suitable control software in order to allow this control process to be carried out.

When using an additional processor μP, it would also be feasible to integrate the means EFM in the processor μP.

The exemplary embodiments which have been mentioned represent only some of the embodiments that are possible by means of the invention. Thus, a person who is skilled in the art and is active in this field will be able to create a large number of further embodiments by advantageous modifications without departing from the character (essence) of the invention - matching of an antenna by moving a dielectric body in the near field of the antenna. These embodiments are likewise also intended to be covered by the invention.